US006827065B2

(12) **United States Patent**
Gottemoller et al.

(10) **Patent No.: US 6,827,065 B2**
(45) **Date of Patent: Dec. 7, 2004**

(54) **DIESEL INJECTION SYSTEM WITH DUAL FLOW FUEL LINE**

(75) Inventors: **Paul Gottemoller**, Palos Park, IL (US); **Michael B. Goetzke**, Orland Park, IL (US)

(73) Assignee: **General Motors Corporation**, Detroit, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/409,485**

(22) Filed: **Apr. 8, 2003**

(65) **Prior Publication Data**

US 2004/0200457 A1 Oct. 14, 2004

(51) **Int. Cl.**[7] **F02M 55/00**
(52) **U.S. Cl.** ..... **123/456**; 123/468; 123/514; 123/198 D
(58) **Field of Search** ..... 123/514, 456, 123/468, 469, 198 D

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,149,568 A	*	4/1979	Kuntz et al.	138/114
4,926,829 A	*	5/1990	Tuckey	123/497
4,955,409 A	*	9/1990	Tokuda et al.	137/561 A
5,076,242 A	*	12/1991	Parker	123/514
5,233,963 A		8/1993	Gregorius et al.	123/456
5,239,964 A	*	8/1993	Diener et al.	123/456
5,560,243 A		10/1996	Wild	73/118.1
6,397,826 B1	*	6/2002	Coleman	123/541
6,499,466 B2	*	12/2002	Lee	123/456
6,604,509 B1	*	8/2003	Hegner	123/456

FOREIGN PATENT DOCUMENTS

DE	19815167 A1	10/1999
DE	10012676 A1	9/2001
EP	1150006 A2	10/2001

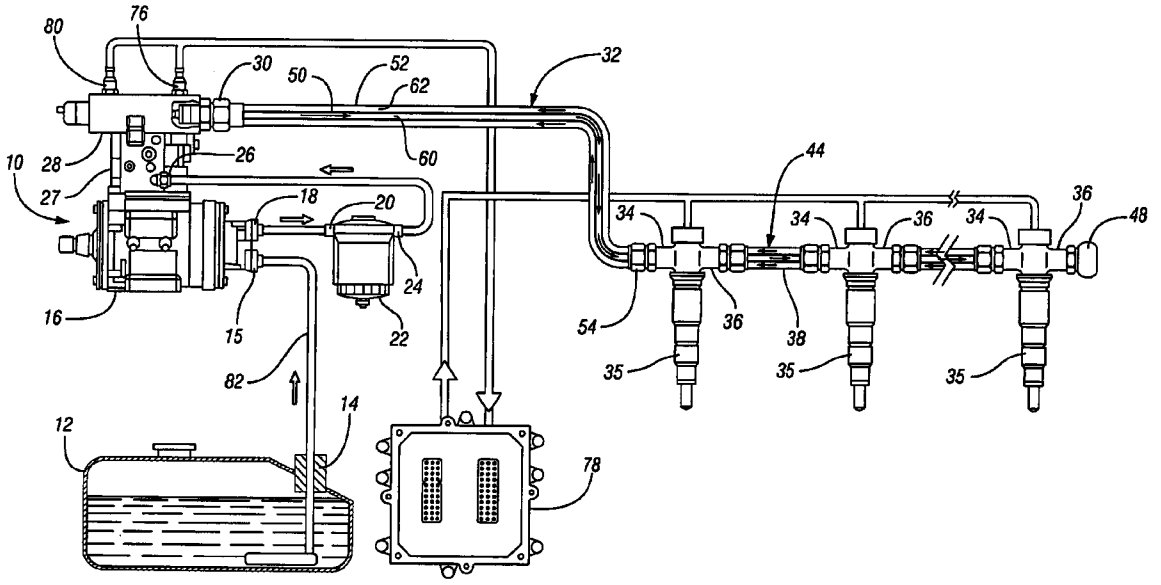
* cited by examiner

Primary Examiner—Thomas Moulis
(74) *Attorney, Agent, or Firm*—Cary W. Brooks

(57) **ABSTRACT**

A double walled fuel line connects diesel fuel injectors in a common rail system. An inner line carries high pressure fuel from a fuel pump to the fuel injectors. Low pressure return fuel flows back through an outer fuel line which acts as a return line. The double walled line reduces the number of separate pipe connections needed in the system and provides protection against loss of high pressure fuel from the system as well as a simplified method for detecting fuel leaks. Monitoring fuel pressure in the low pressure line allows a fuel pressure sensor to detect leaks in the system by comparing fuel pressure in the low pressure line against typical line pressure. Higher than normal pressure in the low pressure line indicates a leak in the high pressure line. Lower than normal pressure indicates a leak in the low pressure return line.

4 Claims, 4 Drawing Sheets



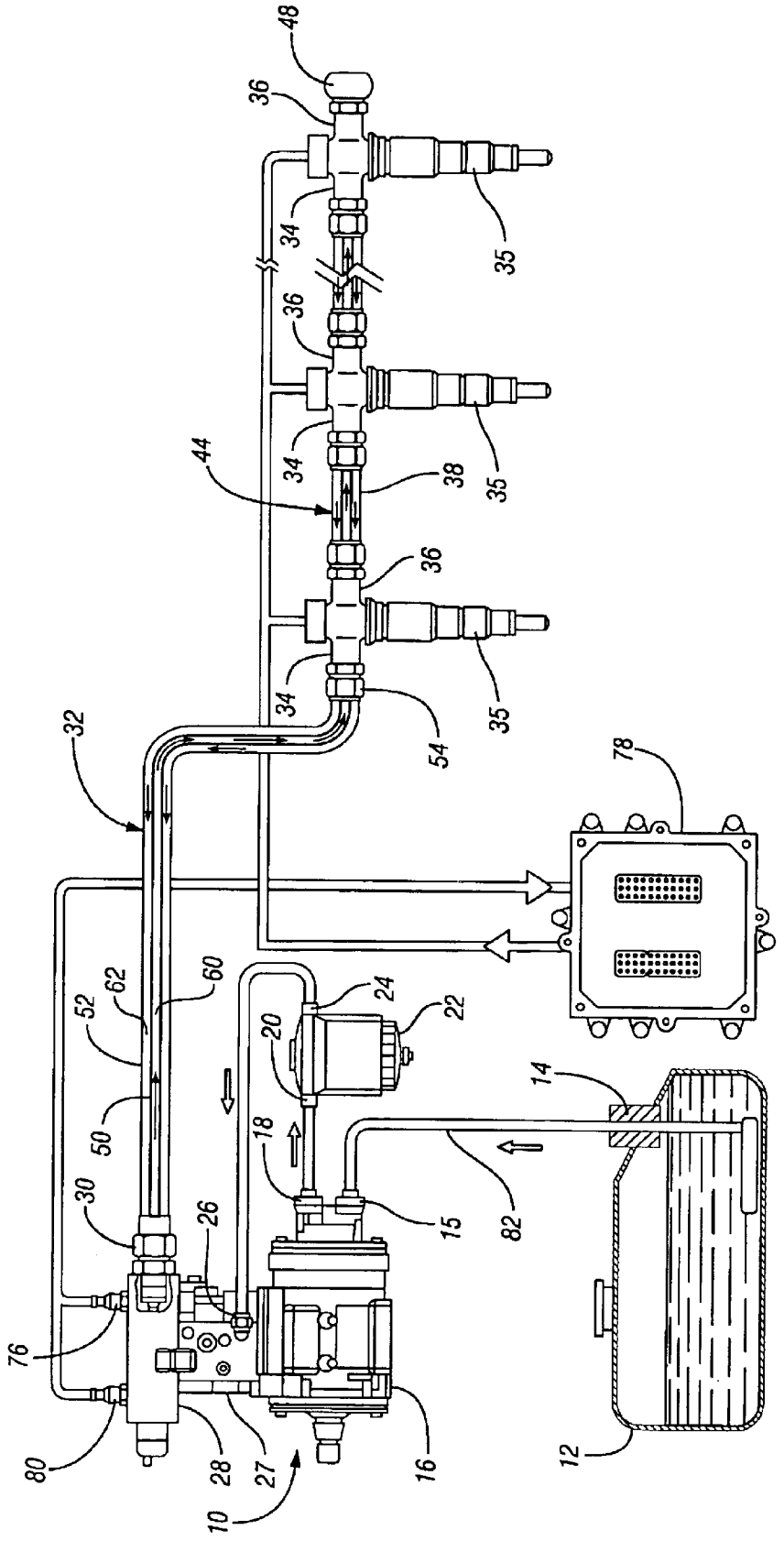

48
36
34
35
36
34
38
35
44
36
34
35
54
32
78
62
60
52
24
22
20
50
14
18
30
26
15
82
76
80
28
27
10
16
12

FIG. 1

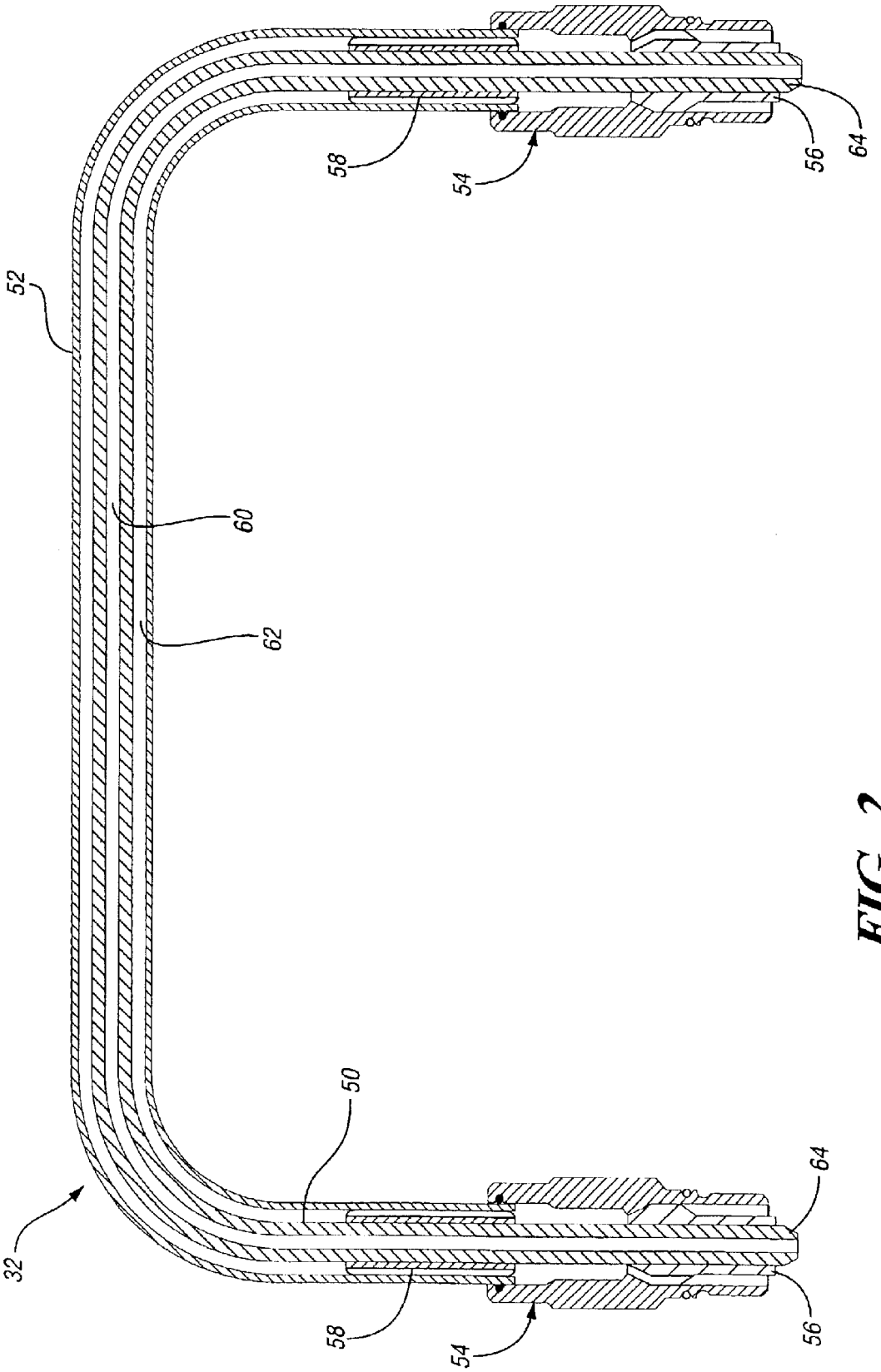


FIG. 2

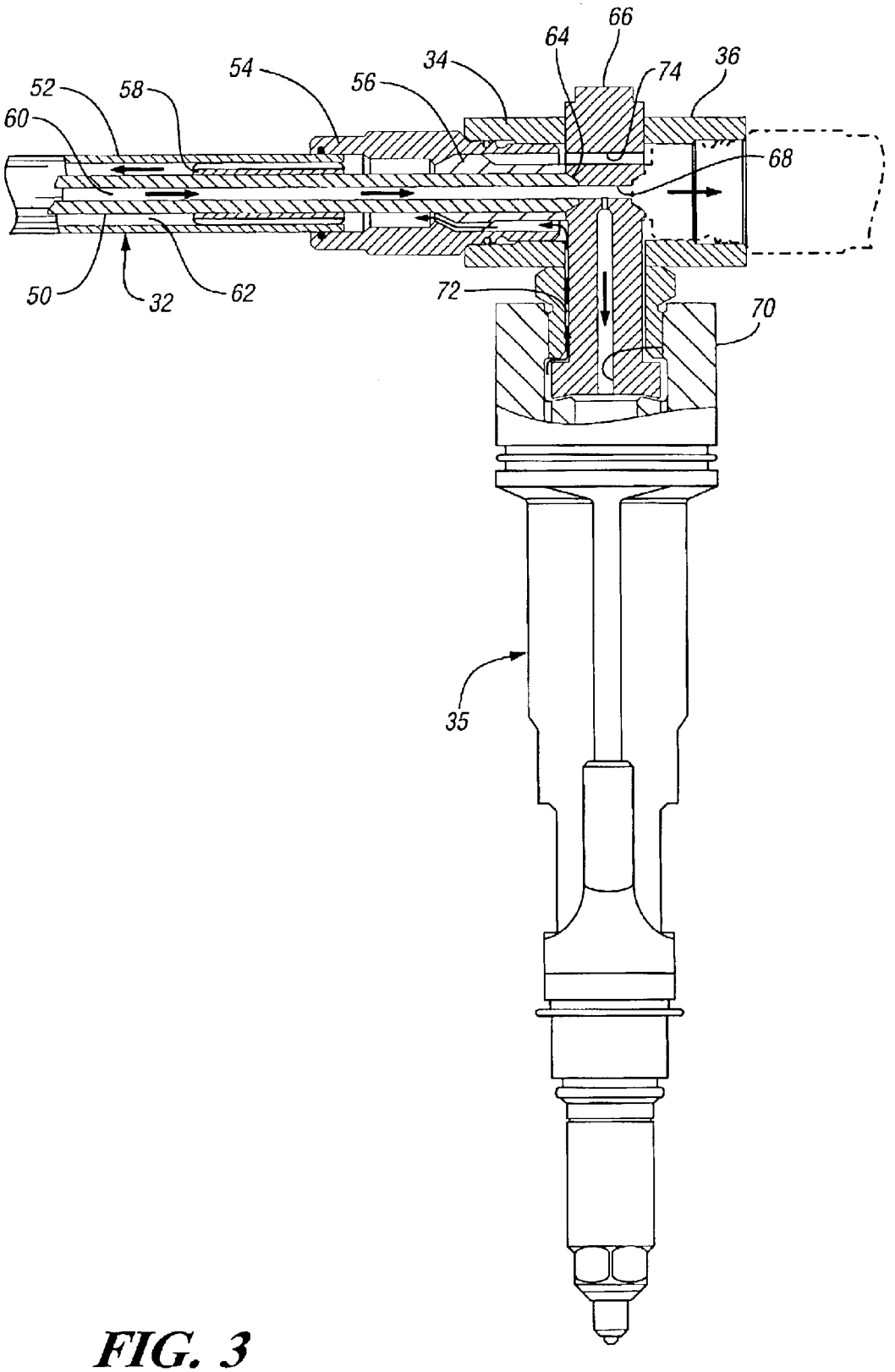


FIG. 3

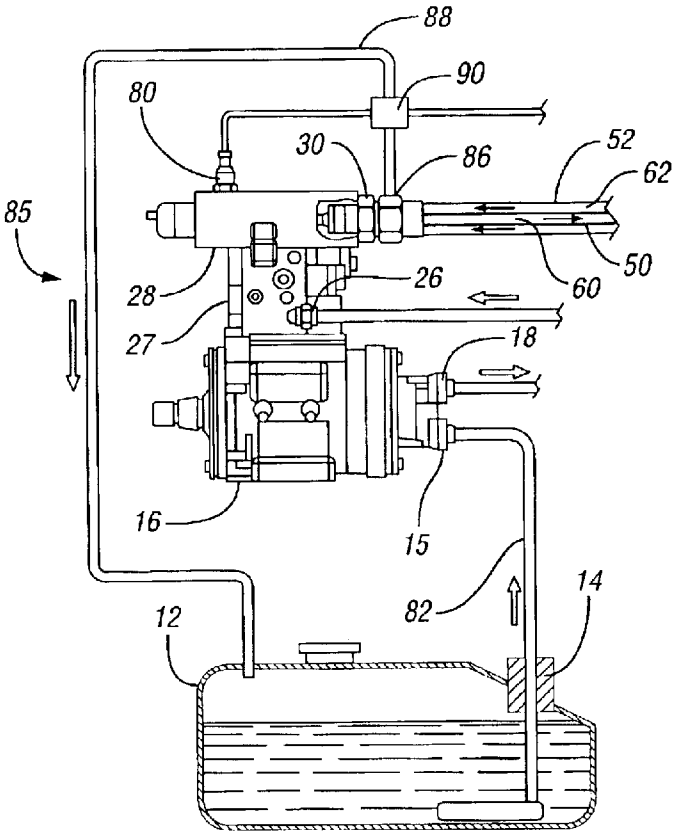

88
90
80
30
86
52
62
85
50
60
28
26
27
18
16
15
82
14
12

FIG. 4

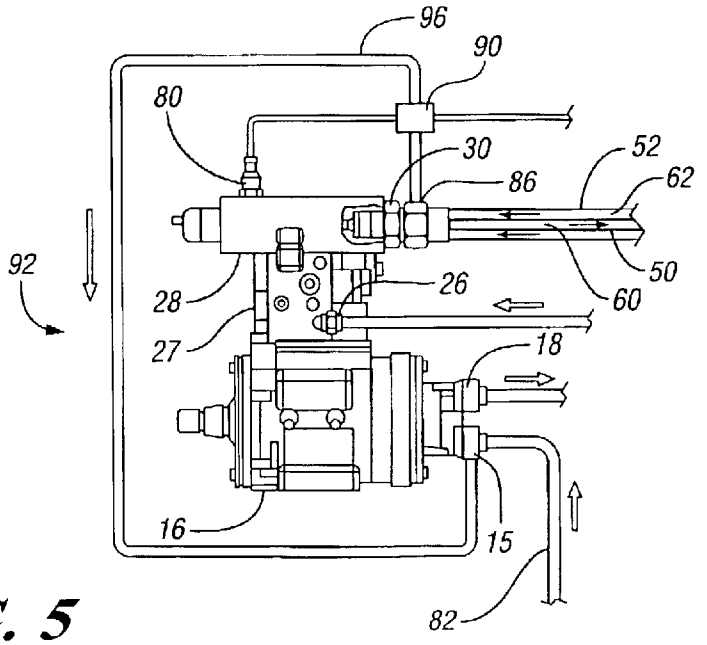

96
90
80
30
52
86
62
92
50
28
26
60
27
18
16
15
82

FIG. 5

DIESEL INJECTION SYSTEM WITH DUAL FLOW FUEL LINE

TECHNICAL FIELD

This invention relates to fuel injection systems for diesel engines.

BACKGROUND OF THE INVENTION

Typical common rail fuel injection systems have one localized high pressure fuel pump connected by serially connected inlet and outlet lines which carry high pressure fuel between the injectors and the fuel pump. The lines connecting to the fuel pump are single or double walled depending upon the application. Double walled fuel lines are currently used to provide additional leak protection around the inner fuel line. Specifically, the inner line is used to carry pressurized fuel while the outer line is kept dry to form an extra barrier between the inner fuel line and the high temperature surfaces in an engine.

SUMMARY OF THE INVENTION

The present invention provides a common rail diesel fuel injection system. The system uses a double walled fuel line having a high pressure inner fuel tube for delivering high pressure fuel from a fuel pump to a series of fuel injectors, and a low pressure outer fuel tube for returning low pressure fuel from the fuel injectors to the fuel pump or the fuel tank. The outer line surrounds the inner line and prevents leaks in the inner line from escaping into the engine compartment. The double walled fuel line provides an additional barrier of protection between the high pressure inner line and the engine as well as a convenient path for fuel flow both to and from the injectors.

Sensing fuel leaks in the system may be accomplished by monitoring fuel pressure in the low pressure fuel line and comparing it against a map of predetermined normal pressures. If a leak occurs in the outer line, the pressure in the line will drop below normal because of lost fuel. If a leak occurs in the inner line, high pressure fuel will flow into the low pressure outer line, increasing fuel pressure in the outer line. Therefore, an increase or decrease in the normal return fuel pressure in the outer line will indicate that there is a leak and whether it is in the inner or the outer line.

These and other features and advantages of the invention will be more fully understood from the following description of certain specific embodiments of the invention taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic view of a fuel injection system according to the present invention.

FIG. **2** is an axial cross-sectional view of a double walled fuel line used in the system of FIG. **1**.

FIG. **3** is a partial cross-sectional view showing the connection of a fuel line with an injector.

FIG. **4** is a fragmentary view similar to FIG. **1** but showing an external fuel return to the fuel tank.

FIG. **5** is a fragmentary view similar to FIG. **4** but showing an external fuel return to the fuel pump inlet.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1** of the drawings in detail, numeral **10** generally indicates a common rail fuel injection system for a diesel engine. System **10** includes a fuel tank **12** having an outlet **14** connected to a metering valve **15** of a low pressure fuel pump **16**. Fuel pump **16** has a metering valve outlet **18** connected to an inlet **20** of a fuel filter **22**. An outlet **24** of fuel filter **22** connects to an inlet **26** of a high pressure fuel pump **27**. An accumulator **28** collects high pressure fuel from the fuel pump **27**.

Accumulator **28** has an outlet **30** connected to a first fuel line **32**, which connects to an inlet **34** of a fuel injector **35**. Fuel injector **35** has an outlet **36**, connected to a second fuel line **38**. Additional fuel injectors **35** and fuel lines **38** are connected in a similar manner to form a common fuel rail **44**. The last fuel injector **35** in the series has an inlet **34** connected to a fuel line, but its outlet **36** has a plug **48** to terminate the common fuel rail.

In accordance with the present invention, fuel line **32** is double walled as shown in FIG. **2**. Fuel line **32** includes a high pressure fuel inner tube **50** surrounded by a low pressure fuel outer tube **52** and a coupling **54** mounted on the ends of both tubes. In one embodiment, the tubes **50**, **52** and the coupling **54** cooperate with an inner collar **56** and a support sleeve **58**. These define a central high pressure fuel passage **60** and a surrounding low pressure return fuel passage **62**, both extending to opposite ends **64** of the fuel line **32**. The fuel lines **38**, which form a common rail connecting a series of fuel injectors **35** preferably have the same construction as the fuel line **32**.

FIG. **3** shows in cross-section the connection of a fuel line, **32** or **38** with the inlet **34** of one of the fuel injectors **35**. Both the inlet **34** and the outlet **36** define sockets connectable with the coupling **54** of the fuel lines **32**, **38**. Thus, the high pressure inner tube **50** directly engages an injector member **66** to connect the central high pressure fuel passage **60** with an internal passage **68** which conducts high pressure fuel through the member **66** to an outlet socket **36**. The internal passage **68** also forms a T-junction with a high pressure inlet passage **70** of the member **66** to direct high pressure fuel into the body of the injector for injection into an engine cylinder.

The inlet an outlet sockets **34**, **36** with fuel lines **32** or **38** also define a low pressure return fuel passage **72** extending from within the injector **35** through the member **66** to the return fuel passage **62** of the fuel line **32**. A low pressure fuel bypass passage **74** also extends between the inlet and outlet **34**, **36** of each fuel injector **35** to allow low pressure fuel to pass from fuel lines **38** to fuel line **32**.

FIG. **1**. shows the outlet **30** of the accumulator **28** connected to fuel line **32**. The outlet **30** of the accumulator **28** is similar to the outlet **36** of the fuel injector **35**, in that it conducts high pressure fuel and receives low pressure fuel in a similar manner. Thus, high pressure fuel is delivered directly into the high pressure fuel passage **60** of the high pressure inner tube **50**. Similarly, return fuel is conducted from the return fuel passage **62** of the fuel line **32** into the body of accumulator **28**. The low pressure entering the accumulator **28** is returned to the inlet **15** of the fuel pump **16** through internal low pressure fuel passages, not shown, to be recirculated into the system. Alternatively, an external low pressure fuel tube may be provided to carry low pressure fuel from the accumulator **28** to the inlet **15** of the fuel pump **16** or to the fuel tank **12** if desired.

A low pressure fuel sensor **76** monitors return fuel pressure in the low pressure fuel return passages. A control unit **78** connects to the fuel pressure sensor **76** to compare the monitored fuel pressure against a normal fuel pressure map to determine if a fuel leak is present in the system **10**.

Alternatively, the low fuel pressure sensor **76** may be located at any convenient location in the low pressure return passage **62** of the first fuel line **32**. A high fuel pressure sensor **80** could also be provided to monitor fuel pressure in the high pressure fuel passage **60**.

In operation, the low pressure fuel pump **16** draws fuel from the fuel tank **12** through a fuel line **82**. The fuel pump **16** sends low pressure fuel through the fuel filter **22** into the high pressure fuel pump **27**. High pressure fuel from fuel pump **27** is pumped into the accumulator **28** where pulsations in the fuel are reduced. The high pressure fuel sensor **80** monitors the fuel pressure inside the accumulator. The high pressure fuel is then delivered through the inner tube **50** of the double walled fuel line **32** and series connected fuel lines **38** to the injectors **35**. The injectors are controlled by the control unit **78** to conventionally deliver timed charges of atomized fuel to associated engine cylinders, not shown.

A small amount of the high pressure fuel leaks past the injection valves, not shown, of the injectors and is returned through the internal low pressure fuel passage **72** to the low pressure return fuel passages **62** of the associated fuel lines **38**, **32**.

Low pressure fuel in the return passages **62** is returned to internal passages, not shown, of the accumulator **28** where its pressure is monitored by the low pressure fuel sensor **76**. The sensor output is fed to the control unit **78** which determines if a leak is present in the system **10**. For this purpose, the indicated pressure of the low pressure return fuel is compared to a map of normal fuel pressures as a function of engine parameters. If a leak in the outer tube **52** occurs, the sensor **76** will detect a below normal fuel pressure, because fuel will escape from the outer tube **52** into its surrounding environment. If a leak in the inner tube **50** occurs, the sensor will detect above normal fuel pressure, because high pressure fuel from the inner tube **50** will escape into the low pressure outer tube **52**. Under normal operating conditions the fuel pressure in the low pressure tube **2** will remain within a normal range.

If a leak is detected in the system, the metering valve **15** is closed, stopping the flow of fuel into the system. The metering valve **15** can also be used to reduce the flow of fuel through the system by partially closing.

Referring now to FIG. **4** of the drawings, numeral **85** generally indicates a variation of the system **10** of FIG. **1** in which like numerals indicate like parts. Thus, low pressure fuel pump **16**, high pressure fuel pump **27**, fuel injectors **35**, and fuel line **32** are physically similar and operate in a similar manner to those of system **10**.

System **85** includes a T-junction **86** at the outlet port **30** of the accumulator **28**. A low pressure fuel return line **88** extends from the T-junction **86** directly to the fuel tank **12**. A low pressure fuel sensor **90** is connected to the low pressure fuel return line **88** between the T-junction **86** and the fuel tank **12** to monitor the return fuel pressure in line **88**.

In operation, all of the initial steps relating to the delivery of fuel to the injectors are the same as system **10**. System **85** differs from system **10** by returning fuel to the fuel tank **12** instead of directly recirculating the fuel back to the low pressure pump through internal passages inside the housing of the pump. The returning fuel exits the double walled fuel line **32** through the T-junction **86** and flows into the low pressure fuel return line **88**. The low pressure fuel returning to the fuel tank **12** passes through the fuel pressure sensor **90** which sends a pressure signal to control unit **78** for use in leak detection as before. The low pressure fuel then returns to the fuel tank **12** where it can be recirculated into the system.

Referring now to FIG. **5** of the drawings, numeral **92** generally indicates a variation of the system **85** of FIG. **4** using most of the same components as indicated by like numerals.

System **92** differs in that the fuel return line **88** of FIG. **4** is replaced by a low pressure fuel return line **96** extending from the T-junction **86** directly to the metering valve inlet **15** of the low pressure fuel pump **16**. A low pressure fuel sensor **90** is connected to the low pressure fuel return line **96** between the T-junction **86** and the metering valve **15** to monitor fuel pressure in line **96**.

Operation of the system **92** of FIG. **5** is identical to that of system **85** of FIG. **4** except for the handling of return fuel. The low pressure fuel returning from the fuel injectors **35** is directed by the T-junction **86** into the low pressure fuel return line **96**, which carries the fuel to the pump **16** metering valve inlet **15**. The returning fuel passes through the fuel pressure sensor **90** which sends a pressure signal to the control unit **78** as before.

While the invention has been described by reference to certain preferred embodiments, it should be understood that numerous changes could be made within the spirit and scope of the inventive concepts described. Accordingly, it is intended that the invention not be limited to the disclosed embodiments, but that it have the full scope permitted by the language of the following claims.

What is claimed is:

1. A common rail fuel injection system for a diesel engine, said fuel injection system comprising:

a high pressure fuel pump operative to supply high pressure fuel for fuel injection;

a double walled fuel line having an inner high pressure fuel tube surrounded by an outer low pressure return tube, the inner tube defining a high pressure fuel passage connected to receive high pressure fuel from the fuel pump and the outer tube defining a low pressure return fuel passage surrounding the high pressure passage;

a series of fuel injectors communicating with the high pressure passage to receive high pressure fuel for injection and communicating with the low pressure passage to deliver low pressure return fuel for reuse in the system; and

a pressure sensor operative to detect changes in fuel pressure in the low pressure passage for use in indicating fuel leaks in either of the high and low pressure fuel tubes.

2. A fuel injection system as in claim **1** wherein the fuel is returned to a fuel tank.

3. A fuel injection system as in claim **1** wherein the fuel is returned to the fuel pump for immediate reuse in the system.

4. A method of detecting fuel leaks in a diesel fuel injection system comprising:

providing a double walled fuel line having a high pressure inner line surrounded by a low pressure outer line;

developing a map of normal fuel pressures in the low pressure line as a function of engine parameters;

monitoring the fuel pressure in the low pressure fuel line; and

comparing the monitored fuel pressure values against the normal values of fuel pressure in the low pressure line to determine if a leak is present.

* * * * *